ADAPTABILITY OF SOME BREAD AND DURUM WHEAT VARIETIES IN EASTERN SAUDI ARABIA [1]

by

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Summary

The performance of improved and local bread and durum varieties of wheat was compared on saline loam soil at the Hofuf Agricultural Research Centre. Improved varieties gave significantly higher yields than local varieties, with shorter stems, earlier maturity and heavier ears. On average, bread wheats were taller and earlier maturing than durum varieties. Ears of bread wheat varieties were, on average, longer but lower in ear weight than those of durum wheat. The mean yield of durum wheat varieties (7,027 kg/ha) was significantly greater than that of bread ones (6,747 kg/ha) .

The yield of bread wheat was closely associated with weight per ear and 100-grain weight, while that of durum wheat was associated more with the density of grains on the ear.

Introduction

Wheat is an important food crop in Saudi Arabia. The total area grown annually is approximately 72,000 ha (Douglas, 1974) . The majority of this area is of durum wheat (*Triticum durum* L.) while the area of bread wheat (*Triticum aestivum* L.) appears relatively small. Wheat occupies approximately 75 per cent of the area cultivated for winter crops and about 16 per cent of the entire cultivated area in Saudi Arabia. Most of the wheat area is concentrated in the three provinces of Central, Qasim and Inner South. Annual production is estimated at 120,000 tons (Saddi, 1974) which is about 27 per cent of the total consumption in Saudi Arabia (Ministry of Agriculture and Water, 1972) . Yields are about 1.5 and 0.8 tons per ha for irrigated and non-irrigated wheats, respectively. As wheat consumption is still relatively small in comparison with other countries of the same culture, the total demand for wheat is expected to increase in the future. In order to meet this demand, an expanded wheat production programme was initiated by the Ministry of Agriculture and Water in 1971.

Although wheat has been under cultivation for many years in Saudi Arabia, it is seldom grown in the Al—Hassa Oasis, the main agricultural area of the Eastern Province situated about 75km inland from the Arabian Gulf. Local rice farmers usually take one

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crop of summer rice and leave much of the cultivated area fallow during the winter season when, in fact, more water is available for irrigation. In addition, several thousand hectares of unreclaimed virgin land, which has been laid out with irrigation canals and drainage ditches as part of a new irrigation system in Al—Hassa, could possibly be used for wheat production in winter. In order to examine the potential of wheat as a winter crop under Al-Hassa conditions, the Chinese Rice Mission at the Hofuf Agricultural Research Centre grew a small plot of red-grained Mexipak wheat (variety Super X) in the winter of 1973. This was highly encouraging, with grain yield of Super X reaching as high as 6 tons per ha (CRM, 1974) . More investigations followed and in the winter of 1974, an experiment was carried out to evaluate some promising new varieties of bread and durum wheats for their adaptation reactions in the area. The results are summarized in this paper.

Materials and Methods

The investigation was carried out at the Hofuf Agricultural Research Centre during the 1974—75 crop season on saline sandy loam soil recently reclaimed from desert. Sixteen varieties or selections (hereafter referred to as 'varieties') consisting of eight each of bread and durum wheats, were evaluated in this trial. They were 1) Arz, 2) Barouk, 3) Tanori 71, 4) Vicame 71, 5) Cajame 71, 6) Kayansona x FAO 215—1—2, 7) Super X, 8) Hinta Medani, 9) Lokaimy, 10) Cocorit 71, 11) Jori 69, 12) Flamingo D—27582—8m —12y—5m—0y , 13) Crane 'S' D—31725—3m—13y—0m, 14) Crane 'S' D— 23055—33m—1ı —3m—0y, 15) Crane 'S' and 16) Brant. Varieties from 1) to 8) are bread wheat and those from 9) to 16) are of durum wheat. Variety 8) , Hinta Medani, is a local bread wheat and variety 9) , Lokaimy, is a local durum wheat. Both varieties were included as controls. The experiment was arranged in a randomized complete block design with four replications. Each plot consisted of six rows 2.5 m long with a row to row spacing of 30 cm. The four inner rows were harvested for the measurement of grain yield.

Seed was sown by hand at a rate of 100 kg per ha on November 30, 1974. The plots received 120 and 80 kg per ha of N (as urea) and P_2O_5 (as triple superphosphate) , respectively. Half of the N and all of the P_2O_5 were applied as a basal dressing prior to sowing while the balance of N was top-dressed at 40 days after sowing. The experiment was irrigated once every 7 to 10 days when there was no rainfall. Weeds were controlled by hand when necessary. Other management practices were at the optimum levels.

Data were recorded for the number of days to heading, number of days to physiological maturity, plant height at muturity, number of ears per square metre, ear length, weight per ear, number of grains per ear, number of grains borne on a unit length of ear (grain density on the ear) , 100-grain weight and grain yield per ha. Data were all subjected to the analyses of variance. Simple correlation coefficients between yield and other agronomic characters were also calculated.

Results and Discussion

Growth Characteristics

The varieties differed significantly in the number of days they took to reach the heading stage (Table 1) . Among the improved bread wheat varieties, the number of days to heading varied from 78 to 87 days whereas those of the improved durum varieties varied from 79 to 85 days. Tanori 71 and Crane 'S'D—23055—33m—1r—3m—0y headed last among the improved bread and durum varieties, respectively. Local bread and durum wheat varieties, Hinta Medani and Lokaimy, both reached the heading stage 99 days after sowing. This was significantly later than improved varieties. There was no significant difference between the mean number of days to heading of bread wheat varieties (83.8 days) and durum wheat varieties (83.6 days) .

The number of days to reach physiological maturity also differed significantly among varieties tested (Table 1) . The improved bread wheat varieties took between 123 and 129 days to reach maturity while the improved durum wheat varieties matured between 128 and 133 days after sowing. Again, both local varieties matured significantly later, taking 136 days to mature. The pattern of varietal difference for the number of days to heading was similar to that of the number of days to maturity, indicating that early heading varieties also matured earlier. In general, bread wheat matured earlier than durum wheat, the difference being statistically significant (Table 1) . Also, the duration from heading to maturity was longer for durum wheat (48 days) than for bread one (44 days) .

The improved bread wheat varieties generally grew taller than their durum counterparts, the means of wheat species being significantly different (Table 1) . With the exception of Vicame 71 and Cajame 71, the two short-statured varieties, the plant height of all improved bread varieties exceeded 90 cm whereas only one of the seven improved durum varieties grew taller than 90 cm. Tanori 71 was the tallest improved bread variety with an average height of 106.3 cm and Cocorit 71 was the tallest improved durum wheat with an average plant height of 93.7 cm. Vicame 71 gave the shortest plant height of 71.6 cm among the varieties tested. Both local varieties were significantly taller than all the improved varieties (Table 1) . The local durum, Lokaimy, gave the greatest height of 126. 2 cm while the local bread wheat, Hinta Medani, had an average plant height of 121.7 cm. Because of their tall plants, more than 80 per cent of plants of local varieties lodged before they reached the heading stage. No lodging was observed in the plots of improved varieties. This indicates that local varieties are less suited to heavy application of nitrogen.

The ears of bread wheat varieties were significantly longer than those of durum wheat varieties (Table 1) . The length of ear ranged from 8.6 to 9.9 cm for bread wheat and 6.6 to 7.9 cm for durum wheat. There was no apparent relationship between ear length and plant height.

The weight per ear of improved durum varieties mostly exceeded three gm while that of improved bread varieties never reached three gm (Table 1) . Most of the varietal differences in ear weight were significant. Among improved durum wheat, Jori 69 gave

the heaviest ear of 3.90 gm while Crane 'S' produced the lightest (2.82 gm) . The heaviest ear produced by the improved bread wheats was 2. 66 gm for Barouk. This was lighter, although not significantly so, than the lightest ear of the durum wheats. Although the average ear length of Vicame 71 was significantly shorter than that of Cajame 71, the average ear weight of Vicame 71 was significantly greater than that of Cajame 71, indicating that factors other than ear length affect ear weight of wheat. The weight per ear, 1.76 and 1.95 gm respectively, of local bread and durum varieties was significantly lighter than those of all improved varieties except that of Cajame 71.

Table 1. Major agronomic characters of wheat*

Variety (code No.)	Days to heading	Days to maturity	Plant height (cm)	Ear length (cm)	Weight/ ear (g)
1.	80.3efg	127.3gh	92.7d	9.3b	2.59ef
2.	79.0gh	127.3gh	103.3bc	9.4b	2.66ef
3.	77.8h	123.0i	106.3b	9.4b	2.65ef
4.	81.0def	125.5h	71.6g	8.6c	2.63ef
5.	87.3b	129.3ef	86.6ef	9.4b	1.82g
6.	84.8c	129.3ef	104.6bc	9.9a	2.47f
7.	81.5de	127.5fg	100.0c	9.6ab	2.79e
8.	98.5a	136.3a	121.7a	9.5ab	1.76g
9.	98.5a	136.5a	126.2a	7.9d	1.95g
10.	79.5fgh	127.5fg	93.7d	6.6h	3.13d
11.	84.3c	133.3bc	85.1ef	7.3ef	3.90a
12.	84.5c	133.8b	89.5de	7.7de	3.34bcd
13.	82.5d	132.3bc	76.0g	7.2fg	3.27cd
14.	78.8gh	128.0fg	84.0f	7.1fg	3.40bc
15.	78.5gh	130.3de	89.2de	6.8gh	2.82e
16.	82.5d	131.8cd	82.0f	7.5def	3.57b
Mean of					
bread wheat	83.8a	128.2b	98.7a	9.4a	2.42b
durum wheat	83.6a	131.7a	90.7b	7.3b	3.30a
C. V. (%)	1.46	0.93	3.44	3.81	5.47

* For each character, any two means of wheat varieties or species with a letter in common are not significantly different at the 5 per cent level.

Grain Yield and Components of Yield

The mean grain yield, number of ears per square metre, number of grains per

ear, 100-grain weight and the density of grains on the ear are shown in Table 2. It can be seen that all improved bread and durum wheat varieties significantly outyielded their respective local control varieties, but none of them yielded significantly better than Super X, the most popular bread variety of improved plant type in Saudi Arabia. Bread wheat variety Barouk recorded the highest yield of 8,219 kg per ha, followed by durum wheat variety Cocorit 71 with 7,970 kg per ha. Another durum variety, Crane 'S' ranked third with a yield of 7,803 kg per ha. The grain yields of Barouk, Cocorit 71 and Crane 'S' were 8, 5 and 2 per cent higher than the 7,626 kg per ha produced by Super X. The other varieties all yielded lower than Super X. The local bread wheat, Hinta Medani, produced the lowest yield of 4,511 kg per ha while Lokaimy, the local durum, gave 4,938 kg per ha, the second lowest yield.

A high yield was also recorded for Barouk at Dirab Agricultural Experiment Station in the Central Province of Saudi Arabia. In a trial conducted in the 1973—74 crop season, Barouk gave 6.81 tons per ha and ranked second among 25 varieties tested (Ministry of Agriculture and Water, 1974) . Another high yielding bread wheat variety which may be of promise in Al-Hassa is Arz. In the present experiment, it yielded 7,532 kg per ha, which was not significantly different from that of Barouk. In the yield trial at Dirab quoted above, Arz produced the highest yield of 6.94 tons per ha. In the present experiment, Arz grew shorter (92.7 cm) than Barouk (103.3 cm) and, therefore, is less likely to lodge with heavy applications of nitrogen.

Cocorit 71 yielded best among durum varieties in this experiment (Table 2) . It has also performed consistently better than the other durum varieties at several locations in Saudi Arabia during the past two years. In the 1972—73 crop, Cocorit 71 ranked first in yield at both Dirab and Taif stations with yields of 6,637 and 4,543 kg per ha respectively (Ministry of Agriculture and Water, 1973). Also, in a trial conducted during the 1973—74 crop season, Cocorit 71 gave the highest yields at El kharj and Taif stations and ranked second at Uneizah Agricultural Experiment Station with yields of 5. 75, 4.36 and 3.56 tons per ha, respectively (Ministry of Agriculture and Water, 1974) . From these results, it appears that Cocorit 71 is well adapted to a wide range of ecological conditions in Saudi Arabia and is also capable of producing a stable yield over a period of years. However, although in terms of yield Cocorit 71 seems suitable for recommendation as a variety for commercial production, its amber coloured grains are a disadvantage since local farmers prefer red grained wheat due to the better market price which it obtains. For this reason, Jori 69, a red grained durum variety, may enjoy greater popularity, although it yielded significantly lower than Cocorit 71 in this experiment (Table 2) .

Table 2. Grain yield and components of yield*

Variety (code No.)	Grain yield (kg/ha)	(%)	Ears/m²	Grains/ear	100-grain weight (g)	Grains/cm of ear
1.	7,532abcde	99	496cd	42.7e	4.70e	4.62f
2.	8,219a	108	559ab	43.5e	4.63e	4.63f
3.	6,949def	91	424ef	44.3de	4.62e	4.73f
4.	6,834def	90	476de	48.8abc	4.19f	5.71d
5.	5,553g	73	507bcd	28.4h	4.32f	3.01i
6.	6,751ef	89	482d	46.4cd	4.13f	4.69f
7.	7,626abcd	100	474def	49.3ab	4.24f	5.15e
8.	4,511h	59	547abc	37.4f	3.29g	3.93h
9.	4,938gh	65	544abc	33.8g	4.17f	4.27g
10.	7,970ab	105	588a	49.0abc	4.95d	7.45a
11.	7,074cdef	93	353g	50.5a	5.96a	6.96b
12.	7,219bcdef	95	347g	43.6e	5.47b	5.71d
13.	7,344bcdef	96	470def	46.8bcd	5.21c	6.50c
14.	7,261bcdef	95	459def	50.2a	5.20c	7.07b
15.	7,803abc	102	486d	43.0e	4.78de	6.31c
16.	6,605f	87	421f	49.1ab	5.49b	6.59c
Mean of						
bread wheat	6,747b	100	496a	42.6b	4.27b	4.56b
durum wheat	7,027a	104	459b	45.8a	5.15a	6.36a
C. V. (%)	6.99		7.10	3.86	3.23	4.53

* For each character, any two means of wheat varieties or species with a letter in common are not significantly different at the 5 per cent level.

The partition of variance for grain yield reveals that the variance associated with yield differences among improved bread varieties was three times larger than that of improved durum varieties, suggesting that the yields of improved bread varieties vary over a wider range than those of improved durum wheat varieties. However, the difference in yield among improved varieties of both wheats appeared much smaller than those which existed between the improved varieties and the non-improved local varieties, as evidenced by the much greater mean square associated with the comparisons of improved varieties versus local varieties for both wheat species (Table 3) . The differences in yield which these mean squares reflect are an indication of the potential increase in wheat production which could be possible in Saudi Arabia with the use of improved varieties.

When averaged across varieties, durum wheat gave a higher yield than bread wheat. The mean yield of durum wheat varieties was 7,027 kg per ha, which was 4 per cent higher than the mean yield of 6,747 kg per ha produced by bread wheat varieties (Table 2) . This difference was significant at the 5 per cent level of probability (Table 3) . In addition to being higher yielding, the quality of durum grain is more suitable for making a special delicacy, called "Harris" in A1—Hassa, which the local people consume during the month of Ramadan, a month of fasting prescribed by the Moslem Faith.

Table 3. Partition of variance for grain yield

Source of variation	Degree of freedom	Mean square	F value
Variety	15	4,419,287	19.09**
Bread wheat	7	5,732,632	24.76**
Improved	6	2,878,352	12.43**
Improved vs. local	1	22,858,309	98.72**
Durum wheat	7	3,558,029	15.37**
Improved	6	827,236	3.57**
Improved vs . local	1	19,942,788	86.13**
Bread vs. durum wheats	1	1,254,680	5.42*

* Significant at the 5 per cent level.

** Significant at the 1 per cent level.

The number of ears per square metre differed significantly among varieties (Table 2) . Durum wheat Cocorit 71 produced the largest number of ears (588) per square metre and another durum variety, Flamingo D—27582—8m—12y—5m—0y produced the smallest number of ears (347) per square metre. The local varieties, Hinta Medani and Lokaimy, produced 547 and 544 ears per square metre, respectively. Differences between local varieties and Cocorit 71 were not significant, suggesting that the number of ears per unit area of wheat varieties is not related to the yields they produce. On average, bread wheat produced more ears per square metre than durum wheat, the difference being statistically significant.

The number of grains per ear also varied significantly among varieties (Table 2) . The durum wheat, Jori 69, recorded the largest number of grains per ear (50.5) while Cajame 71, the lowest yielding improved bread variety, gave the lowest number of grains per ear (28.4) . Local varieties also produced relatively few grains per ear (37.4 and 33.8 for Hinta Medani and Lokaimy, respectively) , showing that varieties with lower yields are usually associated with fewer grains per ear. When averaged across varieties, durum wheat gave a significantly larger number of grains per ear than bread wheat, although the ear of the latter was significantly longer than that of the former. This

indicates that the number of grains per ear is more important than ear length in affecting the weight per ear.

The relationship between ear length and number of grains per ear is more clearly illustrated by the density of grains on the ear, expressed as the number of grains borne per unit length of ear. It was observed that the improved durum wheat varieties generally bore more grains per cm of the ear than the improved bread wheat varieties. The density of grains varied from 5.71 to 7.45 for the improved durum and 3.01 to 5.71 for the improved bread varieties. The local varieties, Hinta Medani and Lokaimy, gave 3.93 and 4.27 grains per cm of ear respectively, which were significantly lower than all improved varieties except that of Cajame 71, the lowest of the improved varieties (Table 2) . Thus, varieties with less grains per unit length of ear tend to produce a low yield.

The 100-grain weight of durum varieties was generally greater than that of bread varieties. The average 100-grain weight was 5.15 gm for durum wheat while that of bread wheat was 4.27 gm, the difference being statistically significant (Table 2) . The durum wheat Jori 69 recorded the heaviest 100-grain weight (5.96 gm) while the local bread wheat, Hinta Medani, gave the lowest (3.29 gm) . It was observed that the 100-grain weight for varieties with lower yields was generally low, suggesting that, like grain number per ear, 100-grain weight is also an important component affecting the yield of wheat. Thus, although varieties of durum wheat produced less ears per unit area than those of bread wheat, this was more than compensated for by the larger number of grains per ear and the greater 100-grain weight. As a result, the average yield of grain per unit area was greater for durum than for bread varieties.

Relationship between Grain Yield and Other Agronomic Characters

Correlation coefficients were calculated to indicate the relationship of yield with other agronomic characters of wheat. The results are shown in Table 4. When varieties of wheat are considered as a whole, yield was shown to have positive correlations with number of grains per ear, weight per ear, density of grains on the ear and 100-grain weight , but it was negatively associated with number of ears per square metre, ear length' plant height, number of days to heading and to maturity. The associations of yield with number of grains per ear and number of days to heading were significant at the 1 per cent level while those of yield with density of grains on the ear, weight per ear and number of days to maturity attained the 5 per cent level of significance. The non-significant correlation which existed between yield and number of ears per square metre seems to indicate that the plant population provided by a seed rate of 100 kg per ha was sufficient for optimum yield. Thus, while the tillering ability of a variety have only a limited effect on the yield of drilled wheat (since an adequate plant population can be obtained by manipulating the seed rate) , characters such as a large number of grains per ear, heavy ears, a high density of grains on the ear and fewer days to heading and maturity appear to be important for high yield potential.

As bread and durum varieties belong to two different species, the correlations of

yield with other agronomic characters were also calculated for each species separately. Table 4 shows that the magnitude of some correlations changed considerably with wheat species, although several were the same for both species. The weight per ear and 100-grain weight was more closely associated with yield in bread wheat than in durum wheat as evidenced by their positive and significant correlations (+0.8627 and+0.7257, respectively). Yield in durum wheat was influenced more by the density of grains on the ear, the correlation coefficient being+0.7240, significant at the 5 per cent level. A positive and significant correlation of yield with 100-grain weight has been recorded previously for bread wheat by Jain and Aulakh (1971) . Since grains of bread wheat varieties are generally lighter than those of durum wheat varieties, the influence of heavy grains on yield is likely to be greater for bread wheat. Similarly, the important role played by the density of grains on the yield of durum wheat can be explained by the fact that ear length of durum wheat is generally shorter than that of bread wheat and, therefore, the number of grains borne per unit length of ear will be more critical to yield in durum varieties.

The correlation coefficients calculated separately for each of the two species also indicate that the negative effects of ear length and plant height on yield were greater for durum than for bread wheates. The correlations of yield with ear length and plant height were-0.5722 and-0.6354 for durum wheat and-0.0271 and-0.2493 for bread wheat, respectively. The association of yield with number of ears per square metre were small and non-significant while those with number of days to heading and to maturity were negative and substantially high. The negative correlation of yield with number of days to heading was significant at 1 and 5 per cent for bread and durum wheats respectively. Jain and Aulakh (1971) also observed a significant and negative association between yield and days to flowering. Substantial correlation also existed in the present experiment between yield and number of grains per ear in both species of wheat, the correlation coefficients of both species being similar in magnitude.

An understanding of the relationship between yield and other agronomic characters can be very useful in breeding for yield improvement in wheat. In the experiment reported here, the yield of bread wheat was found to be significantly affected by the ear weight, number of days to heading and 100-grain weight while that of durum wheat was significantly correlated with the density of grains on the ear and number of days to heading. It appears, therefore, that besides the common character of early heading, selection made for individual plants or lines with heavy ears and grains in bread wheat and a high density of grains on the ear in the durum wheat populations should result in high yielding varieties.

Table 4. Correlation coefficients between grain yield and other agronomic characters of wheat

Character correlated with yield	Correlation coefficient		
	Bread wheat	Durum wheat	Pooled
Ears/m²	— 0.0922	— 0.0042	— 0.0694
Grains/ear	0.6152	0.6239	0.6260**
100-grain weight	0.7257*	0.3466	0.4704
Grains/ cm of ear length	0.5634	0.7240*	0.5285*
Weight/ear	0.8627**	0.4857	0.5734*
Ear length	— 0.0271	— 0.5722	— 0.2306
Plant height	— 0.2493	— 0.6354	— 0.4414
Days to heading	— 0.8474**	— 0.8208*	— 8281**
Days to maturity	— 0.6007	— 0.6690	— 0.0.5027*

* Significant at the 5 per cent level.

** Significant at the 1 per cent level.

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若干普通小麥與硬粒小麥品種在沙烏地阿拉伯王國東方省之適應性

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摘　要

本文係報告中華民國駐沙烏地阿拉伯王國農業技術團於民國64年辦理小麥品種適應性試驗之結果。一般言之，改良品種均較未經改良之當地品種株矮、早熟、穗重而高產。就不同小麥而言，普通小麥較硬粒小麥株高、早熟、穗長而輕。硬粒小麥品種之平均產量（每公頃7,027公斤）顯著高於普通小麥者（每公頃6.747公斤）。前者受一穗着粒密度之影響較大，而後者則與穗重及百粒重之關係較爲密切。

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2.第一作者臺灣省農業試驗所嘉義分所技正兼農藝系主任，現擔任駐沙烏地阿拉伯王國農技團團長，黃係團員，餘爲沙國技術人員。